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Interactive comment on "The role of subpolar deep water formation and Nordic Seas overflows in simulated multidecadal variability of the Atlantic overturning" *by* K. Lohmann et al.

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The authors would like to thank the reviewer for his/her comments, which will improve the manuscript.

Reviewer comment: 1. p.1907, line 10: In closing this section, the reduced explained variability at 30 deg N could and should be attributed to the local (subtropical) influence of variable Ekman transport, although it is not necessary to analyse variability of this component in each model.

Author response: We have calculated the Ekman transport for the MPI-ESM-CR control simulation (where the multidecadal AMOC variance explained respectively by subpolar

deep water formation and Denmark Strait overflow is similar to the multi-model average) and added the following paragraph to the end of section 3 (Analysis of multi-model control simulations):

"One possible explanation for the lower variance explained by SDWI and DSO at 30oN compared to 45oN is the local influence of varying Ekman transport. Time series of the bandpass filtered (15 to 80 years) Ekman transport in MPI-ESM-CR, where the variance explained by SDWI and DSO is similar to the multi-model average (Table 3), show a standard deviation of 0.18 Sv at 45oN, compared to a standard deviation exceeding 0.6 Sv for multidecadal AMOC time series at the same latitude (Figure 6a). At 30oN, on the other hand, a standard deviation of 0.25 Sv is found for the bandpass filtered Ekman transport, compared to a standard deviation of less than 0.4 Sv for the multidecadal AMOC."

Reviewer comment: 2. p.1908, line 22: For clarity, re-label section "4.2 Results of sensitivity experiments"

Author response: Section 4.2 has been re-labeled accordingly.

Reviewer comment: 3. p.1912, line 14: either here, or earlier in Section 5, the caveats associated with coarse resolution should be considered and discussed.

Author response: To discuss the caveats related to the coarse-resolution grid configurations used in our study, we have added the following paragraphs to the end of section 5 (Discussion and conclusions):

"One caveat of our study is the coarse horizontal and vertical resolution of the model grid configurations used. The resolution is non-eddy permitting, with, to some degree, the exception of MPI-AO-LR. Such coarse-resolution grid configurations allow the performance of sufficiently long simulations to ensure robust results on multidecadal time scales, but, on the other hand, lead to model biases, which might affect the realism of the discussed influence of subpolar deep water formation and Nordic Seas overflows on multidecadal AMOC variations. Apart from the unrealistic flow path of the Iceland-Scotland overflow water mentioned above, one major model bias is the location of the subpolar deep water formation site, which also differs among models (Figure 2). Only in MPI-AO-LR, where a higher-resolution grid configuration is used compared to the other models, and in BCM, deep water formation is, as in the real ocean, found in the central Labrador Sea. Another caveat of the model simulations used here is the generally biased representation of the overflow water masses in z-coordinate models (e.g. Willebrand et al., 2001; Danabasoglu et al., 2010; Yeager and Danabasoglu, 2012), resulting in a too shallow meridional overturning cell. Furthermore, the structure of the meridional overturning cell differs among the models, both with respect to mean state and multidecadal variability (Figures 1 and 6). Regarding the latter, also the dominant periodicity varies among models. The largest value of the maximum AMOC strength as well as the largest variability are found in MPI-AO-LR, where a higher-resolution grid configuration is used compared to the other models.

Currently, millennial scale simulations with eddy-permitting or even eddy-resolving grid configurations are not available. The differences among models as well as their biases, however, underline the importance of understanding multidecadal AMOC variability based on simulations with high-resolution grid configurations in the future."

We have also added the differences between MPI-ESM-CR and MPI-AO-LR (higher-resolution grid configuration) to section 3 (Analysis of multi-model control simulations).

Regarding correlation between subpolar deep water formation and AMOC: "In MPI-ESM-CR, correlation coefficients at zero lag or with the AMOC strength lagging are significant only between about 25oN and 50oN. The reason for this difference is not clear, but horizontal resolution might play a role in the MPI model simulations. In MPI-AO-LR, where a higher-resolution grid configuration is used compared to MPI-ESM-CR, significant correlation coefficients extend to higher mid-latitudes as well as into the subtropics (Fig. 3a and b)."

Regarding correlation between Denmark Strait overflow and AMOC: "In MPI-ESM-CR, correlation coefficients south of about 30oN are barely significant. As mentioned above, horizontal resolution might play a role in the MPI model simulations, as MPI-AO-LR, where a higher-resolution grid configuration is used compared to MPI-ESM-CR, shows higher correlation coefficients south of about 45oN (Fig. 4a and b)."

Reviewer comment: 4. p. 1922, Figs. 1 and p. 1928, Fig. 6: Can the AMOC mean and SD be shown northward of 63 deg N? It may be impractical to re-plot, but one is left wondering how the MOC closes (and varies) in the Nordic Seas, as this region is frequently discussed in the text.

Author response: Figures 1 and 6 have been changed accordingly.

Interactive comment on Ocean Sci. Discuss., 10, 1895, 2013.

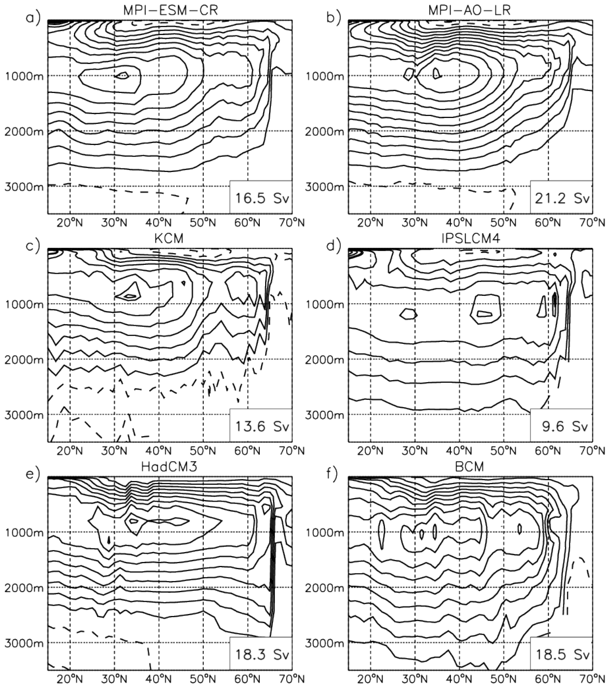
a) MPI-ESM-CR
b) MPI-AO-LR
c) KCM
d) IPSLCM4
e) HadCM3
f) BCM
1000m
2000m
3000m
20°N 30°N 40°N 50°N 60°N 70°N
16.5 Sv
21.2 Sv
13.6 Sv
9.6 Sv
18.3 Sv
18.5 Sv

Fig. 1.

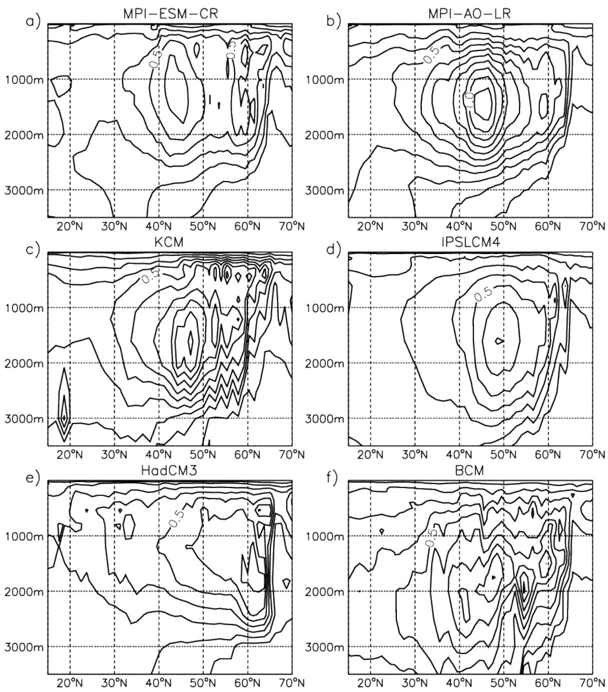
a) MPI-ESM-CR
b) MPI-AO-LR
c) KCM
d) IPSLCM4
e) HadCM3
f) BCM
1000m
2000m
3000m
20°N 30°N 40°N 50°N 60°N 70°N

Fig. 2.